

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0407 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 08/07/00**PART DATA**

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: 17" DISC VALVE ASSY, ORB LH2 BOEING	MC284-0389-1461
LRU	: 17" DISC VALVE ASSY, ET LH2 BOEING	MC284-0389-0602

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

DISCONNECT, LH2 FEED (WITH LATCH) 17 INCH, ORBITER & ET HALF.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY PARKER-HANNIFIN. BOEING IS A CERTIFIED ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: PD2**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

ET/ORBITER FEED LINE DISCONNECT PROVIDES LH2 PROPELLANT TO THE MPS AND A MEANS OF LOADING AND DETANKING THE ET. EACH DISCONNECT HALF CONTAINS A PNEUMATICALLY ACTUATED FLAPPER CLOSURE DEVICE WHICH REMAINS IN ITS LAST ACTUATED POSITION (BISTABLE). THE VALVES ARE CLOSED AFTER MECO TO PREVENT PROPULSIVE VENTING LEADING TO ET/ORBITER RECONTACT, TILE/DOOR DAMAGE DUE TO EXPOSURE TO PROPELLANTS, LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION, AND SYSTEM CONTAMINATION DURING ENTRY. DURING UMBILICAL SEPARATION, THE VALVE SYSTEM IS DESIGNED TO MECHANICALLY CLOSE BOTH THE ORBITER AND ET DISCONNECT FLAPPERS IF UNABLE TO CLOSE THEM PNEUMATICALLY (POST MECO). REDUNDANT OPEN AND CLOSE (TWO EACH) VALVE POSITION SWITCHES ARE LOCATED ON THE ORBITER HALF OF THE DISCONNECT. THE FLAPPER DRIVE MECHANISM IS DESIGNED TO ALLOW RELIEF OF PROPELLANTS TRAPPED BETWEEN THE FLAPPERS AFTER DISCONNECT CLOSURE.

A PNEUMATICALLY ACTUATED LATCH MECHANISM IS PROVIDED TO PREVENT THE VALVE FLAPPERS FROM CLOSING DURING FLOW CONDITIONS. THE LATCH IS BISTABLE AND IS CONTROLLED BY A SEPARATE PNEUMATIC ACTUATOR ASSEMBLY WITH REDUNDANT

FAILURE MODES EFFECTS ANALYSIS (FMEA) --CIL HARDWARE

NUMBER: 03-1-0407-X

LOCK AND UPLOCK (TWO EACH) POSITION SWITCHES. LATCH MECHANISM INCORPORATES TOGGLE PIVOT WHICH ALLOWS FLAPPER CLOSURE DURING BACK UP MECHANICAL SEPARATION WITH LATCH IN LOCKED POSITION. SEE LATCH FMEA/CIL 03-1-0454 FOR ADDITIONAL INFORMATION.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0407-04

REVISION#: 1 08/07/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: 17" LH2 FEEDLINE DISC ORB/ET (PD2)

ITEM NAME: 17" LH2 FEEDLINE DISC ORB/ET (PD2)

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

EXTERNAL LEAKAGE (ET/ORBITER UMBILICAL INTERFACE) DURING LOADING/DRAINING AND ENGINE OPERATION

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

CONTAMINATION, DAMAGED INTERFACE SEAL/SEALING SURFACES, IMPROPER ENGAGEMENT

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

RESULTS IN LH2 LEAKAGE INTO THE UMBILICAL CAVITY. MAJOR PORTION OF LH2/GH2 WILL ENTER THE AFT COMPARTMENT CAUSING POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. LH2/GH2 LEAKAGE EXTERNAL TO THE UMBILICAL MAY CAUSE DAMAGE TO THE VEHICLE AND A FIRE/EXPLOSION HAZARD.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

SECONDARY SEAL IS NOT CONSIDERED REDUNDANT SINCE IT WAS NOT DESIGNED TO SERVE AS A BACKUP TO THE PRIMARY SEAL. THE SECONDARY SEAL WILL PREVENT EXCESSIVE LEAKAGE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. LEAKAGE IS DETECTABLE DURING PROPELLANT LOADING BY HAZARDOUS GAS DETECTION SYSTEM (HGDS).

(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
DESIGN FACTORS OF SAFETY FOR INTERNAL PRESSURE ARE: 1.3 PROOF, 1.5 BURST. PRIMARY MATING SEAL IS DESIGNED FOR LEAKAGE NOT TO EXCEED 600 SCIM OF GH2 AT 0 TO 50 PSIG AND 900 SCIM OF GH2 AT 80 PSIG. A STEEL RETAINING BAND AROUND THE PRIMARY SEAL (TEFLON) PREVENTS SEAL BLOW-OUT DURING SEPARATION.

THE SEALING SURFACES OF THE ORBITER AND ET DISCONNECT ARE FINISHED TO 32 MICROINCH.

SECONDARY SEAL WILL PREVENT EXCESSIVE LEAKAGE BUT IS NOT DESIGNED TO SERVE AS A BACKUP TO THE PRIMARY SEAL. LEAKAGE PAST THE SECONDARY SEAL IS DESIGNED NOT TO EXCEED 10 SCIM OF GHE AT 0 TO 10 PSIG AND 70 TO 160 DEG F. SECONDARY SEAL IS A FEP TEFLON TUBE WITH 302 CRES SPRING INSIDE. THE MAIN PURPOSE OF THE SECONDARY SEAL IS TO PROVIDE A BARRIER FOR LEAK CHECKING THE PRIMARY SEAL.

LEAK DETECTION CAPABILITY IS PROVIDED BETWEEN SEALS FOR AMBIENT CHECKOUT. GUIDE PINS ARE PROVIDED FOR PROPER ENGAGEMENT.

(B) TEST:
ATP (ACTUATOR)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

PROOF: AMBIENT, 1275 PSIG

OPERATIONAL (TWO CYCLES): AMBIENT; 400, 740, 780 PSIG

RESPONSE TIME (OPENING/CLOSING): ROOM AMBIENT/-300 DEG F RESPONSE TIME AT 400, 700 AND 780 PSIG

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ATP - ET/ORBITER MATED DISCONNECT ASSEMBLY

FLAPPER ANGLE: ET 0.75 +/- 0.25 DEG, ORB 2.4 +/- 0.25 DEG

TIP LOAD: ET 55 LB MINIMUM, ORB 40 LB MINIMUM

POSITION SWITCH VERIFICATION: LATCH IN LOCKED POSITION. ROTATION FROM FLAPPER POSITION OF REST ON DOWNSTRIKE SURFACE TO FLAPPER POSITION WHERE OPEN INDICATOR LIGHT TURNS ON MUST BE 4 DEG, MINIMUM.

PROOF: AMBIENT, 1275 PSIG, ACTUATOR
286 PSIG FOR ORBITER CLOSURE DEVICE
58 PSIG FOR ET CLOSURE DEVICE

OPERATIONAL CYCLE: CRYO, -300 DEG F, ACTUATOR PRESSURE 740 PSIG FOR 8 CYCLES AND 450 PSIG FOR 5 CYCLES
AMBIENT, HE AT 400 PSIG (1 CYCLE) AND 740 PSIG (5 CYCLES)

OPERATING TORQUE: ET LH2 SECTION, -410 DEG F FOR 3.5 HOURS MINIMUM, 150 FT-LBS MAX

CLEANLINESS VERIFICATION: MOISTURE FREE AND CLEANED TO LEVEL 400A OF MA 0110-301

LEAKAGE: EXTERNAL

VALVE: LN2/AMBIENT TEMPS: 50 SCIMS OF GHE AT 10 PSIG, 50 SCIMS OF GHE AT 50 PSIG; LATCH SHAFT SEAL, 80 SCIMS OF GHE LH2 TEMPS: 200 SCIMS OF GH2 AT 50 PSIG; LATCH SHAFT SEAL 80 SCIMS OF GH2

VALVE ACTUATOR: CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 TO 0 DEG F)/AMBIENT TEMPS; 100 SCIMS OF GHE AT 740 PSIG

INTERNAL

VALVE: AMBIENT TEMPS: 1000 TO 2500 SCIMS OF GHE AT 1 TO 60 PSIG LN2 TEMPS: 2500 SCIMS OF GHE AT 60 PSIG

VALVE ACTUATOR: CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 TO 0 DEG F)/AMBIENT TEMPS: 100 SCIMS OF GHE AT 740 PSIG

RELIEF OPERATION: -300 DEG F, CRACKING/RESEAT PRESSURE, 0.1-5 PSID (ET ONLY)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP), AND DIELECTRIC STRENGTH

FLOW LINER - ROUNDNESS VERIFICATION (FREE END EIGHT POINTS MEASUREMENT)

OPERATING TORQUE: ET LH2 SECTION SHALL BE MANUALLY ACTUATED (OPEN/CLOSED) AFTER BEING STABILIZED AT -410 DEG F. TORQUE SHALL NOT EXCEED 150 FT LBS.

CERTIFICATION

COMPONENT QUALIFICATION (INCLUDES TESTING FROM PREVIOUS CONFIGURATION WITHOUT LATCH)

SALT FOG

VIBRATION - THREE AXES:

SINUSOIDAL: 5 TO 35 HZ AT 0.25 G, ZERO TO PEAK

RANDOM: 20 TO 2,000 HZ 5.7 G RMS FOR X-AXIS, 5.2 G RMS FOR Y AND Z-AXIS, NO FLOW (LN2), FLAPPERS OPEN, LATCH ENGAGED

THE DISCONNECT IS CHILLED WITH LN2 AND STABILIZED AT -300 DEG F. 10 PSIG DISCONNECT, 740 PSIG ACTUATOR. THESE CONDITIONS ARE MAINTAINED THROUGHOUT SINUSOIDAL AND RANDOM VIBRATION. ACTUATOR VENTED DURING LAST TWO MINUTES OF VIBRATION.

THERMAL CYCLE: -400 TO 150 DEG F, 3 CYCLES

OPERATING LIFE: AMBIENT, 740 PSIG HE FOR A TOTAL OF 2400 CYCLES FOR ORBITER AND 100 CYCLES FOR ET. THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

CRYO, 740 PSIG HE, -400 DEG F FOR A TOTAL OF 1000 CYCLES FOR ORBITER AND 50 CYCLES FOR THE ET. THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP)

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ENGAGE - DISENGAGE: ENGAGE FORCE = 1000 LBS MAX,
DISENGAGE FORCE = 6000 LBS MAX

BURST TEST: PNEUMATIC ACTUATOR, 1700 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

TYPE I AND TYPE II MATED (OPEN POSITION) 450 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

TYPE I AND TYPE II DEMATED (CLOSED POSITION) 330 PSID TO TYPE I, 68 PSID TO TYPE II FOR 2 MINUTES

UMBILICAL SEPARATION TEST: (WITHOUT LATCH)

THE DISCONNECT WAS INSTALLED IN THE UMBILICAL ASSEMBLY DURING THE SEPARATION TEST PROGRAM. THE UMBILICAL ASSEMBLY WAS SUBJECTED TO RANDOM VIBRATION TESTS (4.4 HOURS PER AXIS) WHILE FILLED WITH LN2. THE DISCONNECT WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURES.

UMBILICAL SEPARATION TEST: (WITH LATCH)

FLAPPER PNEUMATICS/LATCH PNEUMATICS/PYROS/RETRACTOR HYDRAULICS

- (1) PNEUMATIC CLOSURE (NORMAL) - 4 CYCLES
- (2) MECHANICAL CLOSURE (BACKUP) - 5 CYCLES

BOTH PERFORMED AT AMBIENT, LN2 AND LH2 CONDITIONS.

FLOW LINER WATER FLOW TESTS: (LH2 VALVE QUALIFIED BY SIMILARITY TO LO2)

DESIGN FLOW TO 13,100 GPM
ALLOWABLE DELTA P IS 10 PSID AT THE LINER

TO DETERMINE THE STABILITY OF THE FLOW LINER. THE FLOW TUBE HAD NO PERMANENT DAMAGE AFTER BEING SUBJECTED TO WATER FLOWS UP TO 20,000 GPM (TEST TIME OF 2 MINUTES / 6 RUNS MINIMUM). AFTER VERIFYING PERFORMANCE AT 20,000 GPM, THE UNIT WAS SUBJECTED TO 22,700 GPM TO VERIFY DESIGN MARGIN (NO PERMANENT DAMAGE).

FLAPPER ANGLE STABILITY MARGIN WATER FLOW TESTS:

ELEVEN (11) EXPLORATORY TEST SERIES (FLOW 4,000 TO 14,200 GPM)
E.T. FLAPPER SETTING VARYING FROM -3.9 TO 2.5 DEG.
ORB. FLAPPER SETTING VARYING FROM -0.9 TO 4.6 DEG.

CERTIFICATION TEST RUN AT WORST CASE PRODUCTION SETTING (FLOW RANGE TO 109% POWER LEVEL).

PRODUCTION ANGLE SETTINGS
E.T. 0.75 +/- 0.25 DEG
ORB. 2.4 +/- 0.25 DEG

FLAPPER TIP LOAD MARGIN WATER FLOW TEST:

SEVEN (7) EXPLORATORY TEST SERIES (FLOW RANGE TO 109% POWER LEVEL)

FLOW 4,000 TO 13,100 GPM
ORBITER: 2.4 +/- 0.1 DEG
TIP LOAD RANGE: 22 TO 60 LBS

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

ET: 0.75 +/- 0.1 DEG
TIP LOAD RANGE: 20 TO 61 LBS

RECOMMENDED TIP LOAD:

ORBITER: 40 LBS MINIMUM
ET: 55 LBS MINIMUM

LATCH WATER FLOW TESTS:

ELEVEN (11) EXPLORATORY TEST SERIES (FLOW 4,000 TO 14,800 GPM)

CERTIFICATION TEST RUN AT NOMINAL PRODUCTION SETTING (FLOW RANGE TO 109%
POWER LEVEL).

TWO PROOF TESTS: 15,650 GPM AND 15,850 GPM

FILL FLOW DIRECTION: SIMILARITY TO LO2 FILL FLOW TEST

LATCH CRYO FLOW TESTS: (LH2 VALVE QUALIFIED BY SIMILARITY TO LO2)

SIXTEEN (16) TESTS WITH LN2/LO2 (FLOWS VARY FROM ONE ENGINE AT 65% TO THREE AT
109%).

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS
CERTIFICATION. ALL MACHINED ITEMS ARE DIMENSIONALLY INSPECTED AND VERIFIED
(MIL-STD-105). CHEMICAL/MECHANICAL PROPERTIES AND RECORDS OF RECEIVED
MATERIALS ARE RETAINED FOR VERIFICATION. BODY FORGING IS ULTRASONICALLY AND
DYE PENETRANT INSPECTED.

CONTAMINATION CONTROL

CLEANLINESS LEVEL TO 400A VIA FREON FLUSH AND SAMPLE VERIFIED. ALL SEAL
GROOVES ARE INSPECTED FOR CLEANLINESS AND EVIDENCE OF DAMAGE.

ASSEMBLY/INSTALLATION

THREADED INSERTS AND CRITICAL DIMENSIONS VERIFIED BY INSPECTION. SEALING
SURFACES ARE VISUALLY INSPECTED FOR DEFECTS. REPAIRED AND REWORKED ITEMS
ARE DIMENSIONALLY CHECKED. LOG OF CLEAN ROOM VERIFIED. ALL ENGINEERING-
DEFINED FEATURES AND SURFACE FINISHES AND TORQUE REQUIREMENTS ARE
COMPLETELY INSPECTED AND VERIFIED.

THE PRIMARY INTERFACE SEAL IS CHECKED FOR ID, OD AND ROUNDNESS. ALL
DIMENSIONS DEFINED IN DRAWING ARE VERIFIED BY INSPECTION.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0407-04**

CRITICAL PROCESSES

HEAT TREATMENT AND PART PASSIVATION ARE VERIFIED BY INSPECTION.

NON-DESTRUCTIVE EVALUATION

PARTS ARE RADIOGRAPHICALLY AND DYE PENETRANT INSPECTED AS IMPOSED BY ENGINEERING IN THE DRAWING REQUIREMENTS.

TESTING

ATP AND TEST MEASUREMENT EQUIPMENT CALIBRATION VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

EXCESSIVE EXTERNAL LEAKAGE WAS OBSERVED AT THE ORB/ET UMBILICAL INTERFACE ON OV-099 FLT 8 (REFERENCE CAR AC9421). THE SEAL WAS REDESIGNED WITH TIGHTER DIMENSIONAL TOLERANCES.

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

FLIGHT:

NO CREW ACTION CAN BE TAKEN.

GROUND:

GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: KOUROSH ANVARI	: /S/ KOUROSH ANVARI
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS